



BEYOND
SMART CITIES

**CERTIFIED INDUSTRIAL ENERGY PROFESSIONAL
CIEP TRAINING PROGRAM**
FOR INDUSTRIAL ENERGY SPECIALISTS
KRISHNAJI PAWAR, LEED AP BD+C, GSAS CGP, ISO 14001:2015, GCP
ENERGY SPECIALIST CURRICULUM

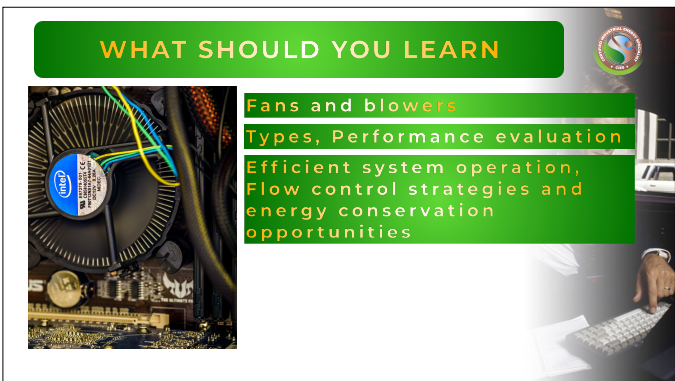




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**FAN SYSTEMS
CIEP TRAINING PROGRAM**
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WHAT SHOULD YOU LEARN



Fans and blowers
Types, Performance evaluation
Efficient system operation,
Flow control strategies and
energy conservation
opportunities

INTRODUCTION

Fans and blowers provide air for ventilation and industrial process requirements. Fans generate a pressure to move air (or gases) against a resistance caused by ducts, dampers, or other components in a fan system. The fan rotor receives energy from a rotating shaft and transmits it to the air.

TABLE 5.1 DIFFERENCES BETWEEN FANS, BLOWER AND COMPRESSOR

Equipment	Specific Ratio	Pressure rise (mmWg)
Fans	Up to 1.11	1136
Blowers	1.11 to 1.20	1136 – 2066
Compressors	more than 1.20	–

✓ Fans, blowers and compressors are differentiated by the method used to move the air, and by the system pressure they must operate against. As per American Society of Mechanical Engineers (ASME) the specific ratio - the ratio of the discharge pressure over the suction pressure is used for defining the fans, blowers and compressors (see Table 5.1).

FAN TYPES

Fan and blower selection depends on the volume flow rate, pressure, type of material handled, space limitations, and efficiency. Fan efficiencies differ from design to design and also by types. Typical ranges of fan efficiencies are given in Table 5.2.



Figure 5.1 Centrifugal Fan



Figure 5.2 Axial Fan

TABLE 5.2 FAN EFFICIENCIES

Type of Fan	Peak Efficiency Range
Centrifugal Fan	
Airfoil, backward curved/inclined	79-81
Modified radial	72-79
Radial	69-73
Pressure blower	56-68
Forward curved	68-65
Axial Fan	
Vane axial	78-85
Tube axial	60-72
Propeller	45-50

✓ Fans fall into two general categories: centrifugal flow and axial flow. In centrifugal flow, airflow changes direction twice - once when entering and second when leaving (forward curved, backward curved or inclined, radial) (see Figure 5.1). In axial flow, air enters and leaves the fan with no change in direction (propeller, tube axial, vane axial) (see Figure 5.2).

CENTRIFUGAL FAN: TYPES

The major types of centrifugal fan are: radial, forward curved and backward curved (see Figure 5.3). Radial fans are industrial workhorses because of their high static pressures (upto 1400 mm WC) and ability to handle heavily contaminated airstreams. Because of their simple design, radial fans are well suited for high temperatures and medium blade tip speeds.

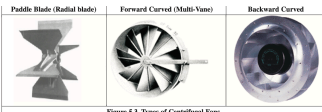


Figure 5.3 Types of Centrifugal Fan

Forward-curved fans are used in clean environments and operate at lower temperatures. They are well suited for low tip speed and high-airflow work they are best suited for moving large volumes of air against relatively low pressures.

Backward inclined fans are more efficient than forward-curved fans. Backward inclined fans reach their peak power consumption and then power demand drops off well within their useable airflow range. Backward-inclined fans are known as "non-overloading" because changes in static pressure do not overload the motor.

AXIAL FLOW FAN: TYPES

The major types of axial flow fans are: tube axial, vane axial and propeller (see Figure 5.4.) Tube axial fans have a wheel inside a cylindrical housing, with close clearance between blade and housing to improve airflow efficiency. The wheel turn faster than propeller fans, enabling operation under high pressures 250 - 400 mm WC. The efficiency is up to 65%.

Tube Axial

Vane Axial

Propeller

Tube Axial

Vane Axial

Propeller

Figure 5.4 Types of Axial Fans

Vane axial fans are similar to tube axials, but with addition of guide vanes that improve efficiency by directing and straightening the flow. As a result, they have a higher static pressure with less dependence on the duct static pressure. Such fans are used generally for pressures upto 500 mmWC. Vane axial are typically the most energy-efficient fans available and should be used whenever possible.

Propeller fans usually run at low speeds and moderate temperatures. They experience a large change in airflow with small changes in static pressure. They handle large volumes of air at low pressure or free delivery. Propeller fans are often used indoors as exhaust fans. Outdoor applications include air-cooled condensers and cooling towers. Efficiency is low approximately 50% or less.

COMMON BLOWER TYPES

✓Blowers can achieve much higher pressures than fans, as high as 1.20 kg/cm². They are also used to produce negative pressures for industrial vacuum systems. Major types are: centrifugal blower and positive-displacement blower.

✓Centrifugal blowers look more like centrifugal pumps than fans. The impeller is typically gear driven and rotates as fast as 15,000 rpm. In multi-stage blowers, air is accelerated as it passes through each impeller. In single-stage blower, air does not take many turns, and hence it is more efficient.

✓Positive-displacement blowers have rotors, which "trap" air and push it through housing. Positive displacement blowers provide a constant volume of air even if the system pressure varies. They are especially suitable for applications prone to clogging, since they can produce enough pressure - typically up to 1.25 kg/cm² - to blow clogged materials free. They turn much slower than centrifugal blowers (e.g. 3,600 rpm), and are often belt driven to facilitate speed changes.

TYPES OF FANS, CHARACTERISTICS, AND TYPICAL APPLICATIONS

Centrifugal Fans			Axial-flow Fans		
Type	Characteristics	Typical Applications	Type	Characteristics	Typical Applications
Radial	High pressure, medium flow, efficiency close to tube-axial fans, power increases continuously	Various industrial applications, suitable for dust laden, moist air/gases	Propeller	Low pressure, high flow, low efficiency, peak efficiency close to point of free air delivery (zero static pressure)	Air-circulation, ventilation, exhaust
Forward-curved blades	Medium pressure, high flow, dip in pressure curve, efficiency higher than radial fans, power rises continuously	Low pressure HVAC, packaged units, suitable for clean and dust laden air / gases	Tube-axial	Medium pressure, high flow, higher efficiency than propeller type, dip in pressure-flow curve before peak pressure point.	HVAC, drying ovens, exhaust systems
Backward curved blades	High pressure, high flow, high efficiency, power reduces as flow increases beyond point of highest efficiency	HVAC, various industrial applications forced draft fans, etc.	Vane-axial	High pressure, medium flow, dip in pressure-flow curve, use of guide vanes improves efficiency/exhaust	High pressure applications including HVAC systems.
Airfoil type	Same as backward curved type, highest efficiency	Same as backward curved, but for clean air applications			

FAN PERFORMANCE EVALUATION AND EFFICIENT SYSTEM OPERATION

✓ **System Characteristics** : The term "system resistance" is used when referring to the static pressure. The system resistance is the sum of static pressure losses in the system.

✓ The system resistance varies with the square of the volume of air flowing through the system. For a given volume of air, the fan in a system with narrow ducts and multiple short radius elbows is going to have to work harder to overcome a greater system resistance than it would in a system with larger ducts and a minimum number of long radius turns.

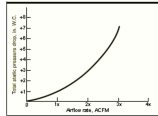


Figure 5.5 System Characteristics

✓ In existing systems, the system resistance can be measured. In systems that have been designed, but not built, the system resistance must be calculated. Typically a system resistance curve (see Figure 5.5) is generated with fan various flow rates on the x-axis and the associated resistance on the y-axis.

FAN CHARACTERISTICS

✓ Fan characteristics can be represented in form of fan curve(s). The fan curve is a performance curve for the particular fan under a specific set of conditions. The fan curve is a graphical representation of a number of interrelated parameters. Typically a curve will be developed for a given set of conditions usually including: fan volume, system static pressure, fan speed, and brake horsepower required to drive the fan under the stated conditions.

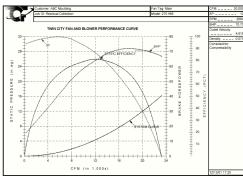


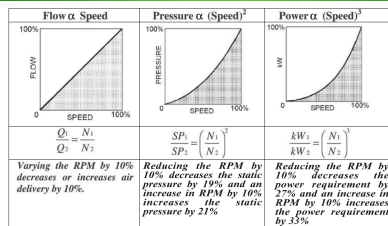
Figure 5.6 Fan Characteristic Curve by Manufacturer

✓ Some fan curves will also include an efficiency curve so that a system designer will know where on that curve the fan will be operating under the chosen conditions (see Figure 5.6). In the many curves shown in the Figure, the curve static pressure (SP) vs. flow is especially important.

✓ The intersection of the system curve and the static pressure curve defines the operating point. When the system resistance changes, the operating point also changes. Once the operating point is fixed, the power required could be found by following a vertical line that passes through the operating point to an intersection with the power (BHP) curve.

FAN LAWS

✓ The fans operate under a predictable set of laws concerning speed, power and pressure. A change in speed (RPM) of any fan will predictably change the pressure rise and power necessary to operate it at the new RPM.



Where Q – flow, SP – Static Pressure, kW – Power and N – speed (RPM)

FLOW CONTROL STRATEGIES

✓ Typically, once a fan system is designed and installed, the fan operates at a constant speed. There may be occasions when a speed change is desirable, i.e., when adding a new run of duct that requires an increase in air flow (volume) through the fan. There are also instances when the fan is oversized and flow reductions are required.

✓ Various ways to achieve change in flow are: pulley change, damper control, inlet guide vane control, variable speed drive and series and parallel operation of fans.

ENERGY SAVING OPPORTUNITIES

Minimizing demand on the fan.

1. Minimising excess air level in combustion systems to reduce FD fan and ID fan load.
2. Minimising air in-leaks in hot flue gas path to reduce ID fan load, especially in case of kilns, boiler plants, furnaces, etc. Cold air in-leaks increase ID fan load tremendously, due to density increase of flue gases and in-fact choke up the capacity of fan, resulting as a bottleneck for boiler / furnace itself.
3. In-leaks / out-leaks in air conditioning systems also have a major impact on energy efficiency and fan power consumption and need to be minimized.



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